

# INCREASE OF ENERGY EFFICIENCY OF THE UKRAINIAN ECONOMY: PROBLEMS AND PRIORITIES

**Vira Chevhanova**

Ph.D., Poltava National Technical Yuri Kondratyuk University, e-mail: vera\_chevhanova@list.ru,  
Poltava, Ukraine

**Oleksandr Khadartsev**

Poltava National Technical Yuri Kondratyuk University, e-mail: alexkhadartsev@ukr.net,  
Poltava, Ukraine

**Abstract.** The article deals with the factors which slowing down the energy efficiency processes of Ukraine's economy. To identify existing problems the structural-functional and value engineering analysis of energy consumption dependence on conditions of economic environment been made. The priority directions and instruments to intensify energy efficiency policy in Ukraine been suggested.

**Keyword:** energy efficiency, energy consume, sector of the economy, share of energy, cost of energy.

## Introduction

Modern paradigm of normal functioning of the economy determine a plenitude of demand for energy resources as one of the dominating factors for almost all countries. The solidity of the energy needs can be achieved by having sufficient and stable resource and energy base, on the one hand, and by providing efficient use of energy resources, with improvement and development of energy supply, on the other hand. The phenomenon of the world economic experience, such as the "resource curse" and "Dutch disease", shows the advantages of the second way of meeting the energy needs of the economy.

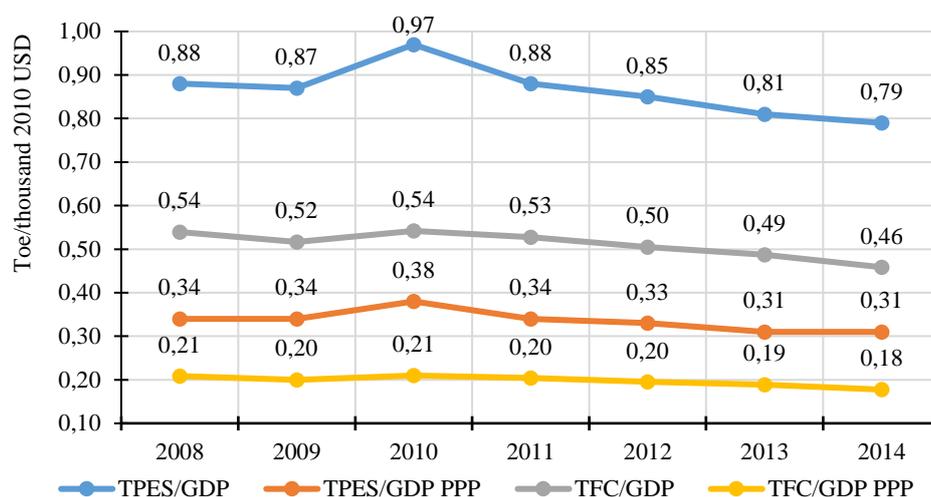
Ukraine is characterized by high unit costs of energy resources in almost all economic activities. Besides, Ukrainian economy has a significant dependence on import of energy and hydrocarbons. Despite some progress in energy efficiency, which have occurred in recent times, the processes of implementation of projects and activities to improve energy efficiency occur rather slowly, selectively and not systematically. Therefore, there is a need for a detailed structural analysis of complex trends of energy consumption of the Ukrainian economy. It will help to identify topical problems and to suggest priorities for improving energy efficiency.

## Key trends of energy efficiency in Ukraine

Research of energy efficiency requires the selection of adequate methodology for analyzing and building the relevant indicators. According to the International Energy Agency (IAE) methods, energy expenditures are measured in millions or thousands tons of oil equivalent (Mtoe, Ktoe). Major indicators of energy efficiency evaluation are the total primary energy supply (TPES) per one-dollar GDP and per one-dollar GDP at purchasing power parity (TPES/GDP, TPES/GDP PPP). Thus, the difference of the currency rate embedded in the calculation of purchasing power parity can significantly affect at the efficiency indicator. Together with the total primary energy supply, energy balance provide information about the total final consumption (TFC) that allows performing calculation of the final energy expenditures per GDP (TFC/GDP, TFC/GDP PPP).

The trends of specific indicators of energy expenditure for 2008-2014 shows a slight increase of efficiency of Ukrainian economy (fig. 1). In 2014 GDP amounted to 134.02 billion 2010 USD that 1.15 times less than in 2008, and TPES amounted 105.68 Mtoe, or decreased compared to 2008 1.27 times. However, TFC for this period decreased in 1.35 times. Thus, the ratio of TFC/TPES decreased from 0.62 in 2008 to 0.58 in 2014, reflecting the negative impact of the effect of scale on energy efficiency (Shevtsov, 2014). It should be noted, that the ratio between final consumption and primary energy supply is characterized as a conversion efficiency of energy resources, and specific types of economic activities in the country. In particular, in 2014 the ratio of TFC/TPES for individual countries was Germany – 0.71, France – 0.61, Poland – 0.69, Belarus – 0.73. However, in the context of a comparison of the individual European countries for TPES and GDP statistics are not for the benefit of Ukraine. Therefore, in 2014 TPES in Germany totaled 306.07 Mtoe, which exceeded the Ukraine 2.89 times. While Germany's GDP was 3624.17 billion 2010 USD, surpassing value Ukraine in 27.04 times. France (2.29 and 20.37) and Poland (0.89 and 3.99) give a similar ratio.

The low energy efficiency of the economy also worsens due to the weakness of the national currency (Ukraine, 2012). In 2014, the divergence of energy efficiency for TPES/GDP and TPES/GDP PPP was 2.55 times for Ukraine, for Germany – 0.89 times, France – 0.9 times and Poland – 1.64 times. Decline of the hryvnia creates favorable conditions for export-oriented sectors of Ukrainian economy, on the one hand, however, but leads to non-motivation energy efficiency in industry, on the other hand.



**Figure 1. Ukrainian energy efficiency in 2008-2014** (IEA statistics, <http://www.iea.org>)

Taking into account the share of imported energy in the structure of energy supply, following adverse implications displayed on economic activity and the welfare of the population.

### The changes of energy supply and consume in Ukraine

The dynamics of energy efficiency essentially depends on changes in species and product structure of energy use. During 2008-2012 in Ukraine, the basic sources of primary energy supply were coal and natural gas, which is used for conversion to other forms of energy and to final consumption, and nuclear energy, which is converted into electricity. Against the backdrop of trends in the reduction of energy coal and natural gas, increased the volume of oil products (table 1). The positive trend was the growth in the share of alternative sources of energy (geothermal, solar, etc.): from 4 Ktoe in 2008 to 134 Ktoe in 2014, but its share in the primary balance in 2014 was only 0.13%. At the same time in Germany, the share of alternative sources amounted to 2.89%, in France – 0.97%, in Poland – 0.74%.

**Table 1. Share of TPES and TFC in 2008-2014**

Indicator	Ukraine								Germany		France		Poland	
	2008		2010		2012		2014		2014		2014		2014	
	Ktoe	%	Ktoe	%										
<b>TPES, total</b>	<b>134642</b>	<b>100,00</b>	<b>132428</b>	<b>100,00</b>	<b>122512</b>	<b>100,00</b>	<b>105683</b>	<b>100,00</b>	<b>306070</b>	<b>100,00</b>	<b>242642</b>	<b>100,00</b>	<b>94018</b>	<b>100,00</b>
coal	41799	31,04	38251	28,88	42545	34,73	35576	33,66	79602	26,01	9288	3,83	49313	52,45
crude oil	11166	8,29	11497	8,68	5073	4,14	3043	2,88	94012	30,72	55459	22,86	24640	26,21
oil products	3202	2,38	1682	1,27	6559	5,35	7645	7,23	7000	2,29	14790	6,10	-2655	-2,82
natural gas	52805	39,22	55229	41,70	43019	35,11	33412	31,62	63356	20,70	32585	13,43	13401	14,25
nuclear	23566	17,50	23387	17,66	23653	19,31	23191	21,94	25312	8,27	113748	46,88	0	0,00
hydro	990	0,74	1131	0,85	901	0,74	729	0,69	1684	0,55	5403	2,23	188	0,20
geothermal, solar, etc.	4	0,00	4	0,00	53	0,04	134	0,13	8842	2,89	2350	0,97	698	0,74
biofuels and waste	1689	1,25	1597	1,21	1695	1,38	1934	1,83	29179	9,53	14792	6,10	8218	8,74
electricity	-579	-0,43	-349	-0,26	-987	-0,81	-725	-0,69	-2914	-0,95	-5778	-2,38	186	0,20
heat	0	0,00	0	0,00	0	0,00	745	0,70	-3	0,00	5	0,00	29	0,03
<b>TFC, total</b>	<b>82872</b>	<b>100,00</b>	<b>73933</b>	<b>100,00</b>	<b>72548</b>	<b>100,00</b>	<b>61460</b>	<b>100,00</b>	<b>216322</b>	<b>100,00</b>	<b>147652</b>	<b>100,00</b>	<b>65271</b>	<b>100,00</b>
coal	10068	12,15	7987	10,80	8717	12,02	9180	14,94	6787	3,14	3158	2,14	11861	18,17
crude oil	0	0,00	10	0,01	9	0,01	8	0,01	0	0,00	0	0,00	0	0,00
oil products	13532	16,33	12548	16,97	12481	17,20	10141	16,50	92099	42,57	67305	45,58	20952	32,10
natural gas	34147	41,20	28396	38,41	26605	36,67	20955	34,10	49942	23,09	28228	19,12	10406	15,94
nuclear	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
hydro	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
geothermal, solar, etc.	0	0,00	0	0,00	0	0,00	0	0,00	709	0,33	129	0,09	37	0,06
biofuels and waste	1207	1,46	984	1,33	1030	1,42	1201	1,95	13532	6,26	10898	7,38	5744	8,80
electricity	11612	14,01	11526	15,59	11839	16,32	11041	17,96	44104	20,39	35718	24,19	10824	16,58
heat	12306	14,85	12481	16,88	11865	16,35	8933	14,53	9148	4,23	2217	1,50	5446	8,34

(Calculation based on IEA statistics, <http://www.iea.org>)

Illustrative is the differences of fractions of biofuels and waste as energy sources. In Ukraine for 2008-2014 this share was only 1.25-1.83% with relatively little change in the volume of biofuel proposals (from 2008 to 2014 growth was 15%). In 2014 in Germany the share of biofuel and waste held 9.53% of primary supply, in France

6.1%, in Poland – 8.74%. Despite the fact that the primary supply in Poland was at 1.12 times less than in Ukraine, initial supply of biofuel prevails in 4.25 times.

Structural changes for 2008-2014, which occurred in TFC and TPES, do not show the steel trends of optimization of energy consumption, but due to the impact of situational factors of economic environment. The largest share of TFC accounted for industry and residential: in accordance with 33.47% and 33.17% in 2014, the share of transport amounted to 16.8%. In Ukraine, the industry and the residential identified as the sectors, which have the biggest potential for energy savings. Industry is the largest final consumer of coal (91.59%). The largest final consumers of electricity: residential (43.62%), industry (35.73%), commercial and public services (18.26%). Natural gas in final energy consumption accounted for most on the residential (56.04%) and industry (15.86%). In industry, the natural gas consumption dropped from 9687 Ktoe in 2008 to 5272 Ktoe in 2012, and 3324 Ktoe in 2014. This reduction is primarily associated with a decrease in the volume of industrial production and with the modernization of individual enterprises of metallurgical complex. In particular, the gross added value of industry from 2008 to 2014 in terms of comparable prices decreased by 42.5%, industrial consumption of electricity decreased by 18%, but increased by 7% industrial consumption of coal. Also, the share of biofuels and waste used by Ukrainian industry varies on the level of 4-4.5%, while in Germany – 27.59%, France – 11.89%, Poland – 31.96%.

Volumes and dynamics of the vertical structure of TPES and TFC indicates that the potential for energy efficiency is being implemented slowly, despite all efforts of the government, the public and the support of international organizations (Uglublenny, 2013). State Energy Efficiency Program for 2010-2015, developed with the support of international organizations, intended to achieve a number of objectives, including:

- to reduce the energy capacity of GDP by 20% compared to 2008;
- to increase the share of renewable energy up to 10%;
- to reduce the cost of natural gas for the production of heat by 60%;
- to reduce energy costs for government agencies by 50%;
- to increase the annual replacement of imported natural gas from other sources by 12.2 Mtoe.

However, the efficiency of the economy depends on technical and technological characteristics of the consumption and the cost of energy. Thus, by analytical estimates the cost of 1 toe imported energy resource in 2008 amounted to 349.8 USD, in 2012 – 563.0 USD, in 2013-2014 there was its reduction to 21.8%. These trends have a negative impact on the overall value of the imported energy supplies, as leveling the physical reduction of import (Mel'nyk, 2016). Accordingly, the capacity of energy policy is not only a necessity for technical optimization of energy use, but also change the comparative value of energy in terms of the potential consumer. Activation of energy efficiency is to create conditions of economic interest to businesses in maximizing the useful output from each unit of energy resource.

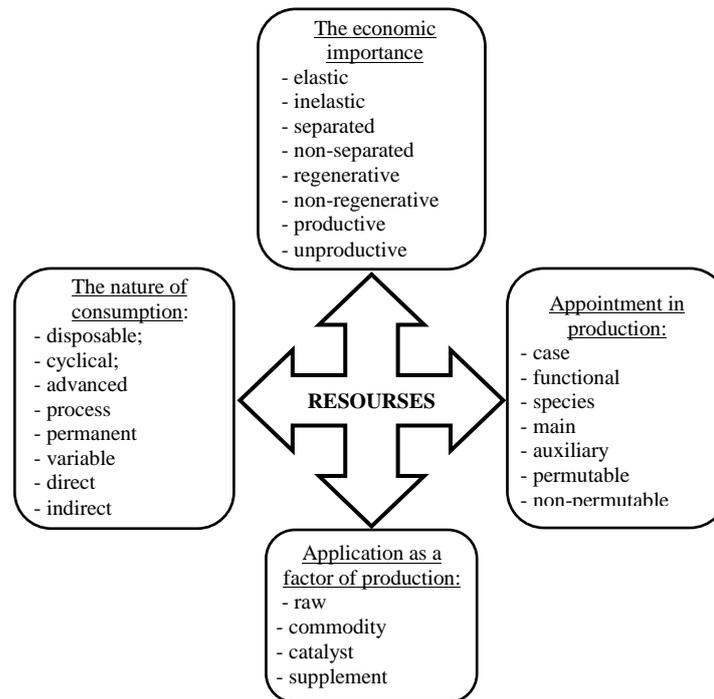
### **Specific of energy use in sectors of the economy**

The level of energy consumption by individual sectors of the economy depends on a number of technical and economic factors. The combination of key parameters, such as availability, price, quality, interchangeability, direction and the flexibility of the application, forms the demand for energy resources and specificity of their use. From a consumer perspective, the entity role of each resource (including energy) is determined through the complex of a particular set of characteristics. Therefore, the improvement of energy efficiency, in terms of a business entity, is not the goal but strategy or means of achieving economic interests and benefits. Extensive strategy, as a rule, is carried out at the expense of expanding involvement of energy resources in production process. These resources have less absolute and/or specific value according to the source of technical and economic characteristics. The resources-substitutes have related or identical properties for the economic relevance for the economic process, the purpose of the economic activities, using as a factor of production or the nature of consumption in economic activity (fig. 2). In contrast, intense strategy is carried out by increasing the efficiency of energy use by introducing innovations and achievements of scientific and technological progress, enhancing existing and establishing new production and business operations, processes and forms of organization of economic activity.

Together with the quantitative and structural differences in energy consumption between Ukraine and Europe, there are also substantial differences in prices for energy resources. Studies point to the issue of the functioning of the market mechanisms for stimulate namely excessive government regulation of the energy market. Like this, in Ukraine tariffs for industrial consumers significantly above the market price and tariffs for the population does not cover a half of the costs, while in the EU the alignment is opposite: in France the average price of electricity for households in 1.85 times higher than price for industrial sector, in Germany – 2.24 times. The average EU households pay for electricity in 2.16 times larger than in industry. The average cost of natural gas for households (at the exchange rate on November 2015) in Europe in 2.52 times higher than in Ukraine. In particular in Germany – 2.57 times, France – 2.66 times, Sweden – 4.29 times. Price of gas for industry in EU is almost the same and exceed the Ukrainian price only by 4%/ (Yevropeys'kiy, 2015).

This price disparity reflects the policies of European countries to stimulate the productive use of energy

resources and optimization of non-productive consumption. The level of economic development and the welfare of its citizens caters to energy needs in extent. The rising cost of energy would promote transformations that is more dynamic, in order to energy efficiency of the Ukrainian economy.



**Figure 2. Resources systematization for their value in economic activity** (developed by the authors)

The analysts of the German Advisory Group (Mayssner, 2012) highlights the main issues that need be resolving at the government level:

- administrative pricing, subsidies and cross-subsidies which distort prices of energy resources;
- lack of competition and inefficient use of energy as a result of the existence of state property and vertically integrated monopolies;
- lack of a proper legislative framework governing legal relations in the residential sector and in the other energy-related areas.

Along with the above factors, significant impact carry out specific terms and conditions of business activity, trends and economic conditions in general. It is reflected on the horizontal structure of the energy consumption (table 2). By approximate calculations in Ukraine cost (scaled according to the NBU exchange rate and to the established prices and tariffs) 1 toe of electricity amounted to: 2012 – 185.54 USD for the households and 577.78 USD for the industry; 2014 – USD 143.54 for the households and 465.69 USD for the industry. Cost of 1 toe of natural gas: 2012 – 169.19 USD for the households and 611.39 USD for the industry; 2014 – USD 134.69 for the households and 416.81 USD for the industry. While it occurred the growth of the prices on energy resources in hryvnia equivalent.

For export-oriented enterprises, which receive the currency earnings, such a situation does not stimulate the implementation of comprehensive and systematic measures of energy efficiency. In accordance, the growth of the actual cost of energy falls on households and domestic business. These categories due to certain financial limitations forced to not how many implement intensive strategy efficiency, as extensive even limiting consumption. The latest trends in energy price increase occurred with the growth of the rate of USD.

Thus, the cost of energy for 1 toe in 2016 was as follows: by electricity is 160.07 USD for the households and 326.90 USD for the industry; by natural gas – USD 336.96 for the households and 321.12 USD for the industry. More accurate and likely calculation requires taking into account all the scenarios of energy consumption, market dynamics, and the economic efficiency of production and the welfare of the population. It will allow to getting an adequate evaluation and forecast of energy efficiency. Therefore, along with ahead of Ukraine according to the GDP, the EU has the highest standards of life of the population, which is reflected in the greater energy consumption per capita and in the sector of commercial and public services. That is why the increase of electricity consumption can reveal not about the reducing of energy efficiency, but about a greater level of household needs.

Analysis of the horizontal structure of the TFC by industry shows that during 2008-2014 significantly changed the ranges between coal and natural gas. In 2008, the share of natural gas was 32.08% and coal was 26.01%

in energy consumption, in 2014, it changed to 16.16% and 40.88% respectively. This also increased the share of electricity from 19.12% to 22.74%.

**Table 2. Share of energy consumption by sectors of the economy in 2008-2014**

Indicator	Ukraine				Germany	France	Poland
	2008	2010	2012	2014	2014	2014	2014
<b>Industry</b>	<b>100,00</b>						
coal	26,01	27,29	31,08	40,88	10,54	10,69	26,27
oil products	4,68	5,46	5,19	4,48	5,14	8,75	5,03
natural gas	32,08	25,81	21,98	16,16	34,09	38,54	22,57
biofuels and waste	0,18	0,16	0,19	0,23	6,80	5,01	12,96
electricity	19,12	22,73	22,62	22,74	35,85	37,01	29,18
heat	17,94	18,55	18,94	15,52	7,58	0,00	4,00
<b>Transport</b>	<b>100,00</b>						
coal	0,22	0,21	0,10	0,07	0,00	0,00	0,00
oil products	61,65	68,24	75,74	70,80	92,30	90,65	91,53
natural gas	32,19	25,57	17,39	22,01	0,82	0,21	2,31
biofuels and waste	0,00	0,00	0,00	0,40	5,07	6,67	4,51
electricity	5,95	5,98	6,77	6,72	1,81	2,46	1,66
heat	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<b>Residential</b>	<b>100,00</b>						
coal	3,31	2,00	3,04	1,42	1,12	0,40	33,47
oil products	0,42	0,34	0,24	0,16	23,62	16,61	3,22
natural gas	60,51	59,00	58,68	57,61	35,67	28,88	16,58
geothermal, solar, etc.	0,00	0,00	0,00	0,00	1,19	0,23	0,14
biofuels and waste	4,76	3,83	3,99	5,25	9,54	16,31	13,29
electricity	11,75	13,26	14,08	16,44	21,73	34,44	12,75
heat	19,25	21,56	19,97	19,12	7,14	3,13	20,54
<b>Commercial and public services</b>	<b>100,00</b>						
coal	4,64	3,81	2,62	1,57	0,16	0,51	8,60
oil products	1,23	1,59	1,56	2,29	21,45	10,89	5,58
natural gas	10,82	7,50	9,25	17,93	30,29	29,07	20,65
geothermal, solar, etc.	0,00	0,00	0,00	0,00	0,30	0,14	0,13
biofuels and waste	0,87	0,26	0,54	0,60	6,44	2,25	2,77
electricity	39,50	35,41	39,54	43,23	37,34	53,85	49,88
heat	42,91	51,41	46,49	34,40	4,03	3,30	12,39

(Calculation based on IEA statistics, <http://www.iea.org>)

In Germany and France, the share of the coal does not exceed 11%, but in Poland – up to 27%. For the residential, the main source of energy is natural gas (60.51-57.61%), heat energy (about 20%) and electricity (11.75-16.44%). Despite the higher relative cost of 1 toe of electricity to natural gas, households are inherent to the substitute of natural gas with electricity. The substitution process caused by the rising cost of energy in UAH in 2012-2014:14.97% for electricity and 18.31% for gas. This prompted to save energy and change the structure of energy needs. In 2014-2016, the price for the households in UAH by electricity has increased on average at 2.36 times, by natural gas – 5.3 times. Therefore, the cost changes will lead to further structural shifts in energy consume.

Thus, the indicators of the energy efficiency should be built and correct taking into account technical, economic, organizational, financial and market features of the functioning of certain sectors of the economy. Application of this methodological approach will accurately delineate the impact of intensive and extensive factors of energy consumption.

### Conclusions and suggestions

The Ukrainian energy policy needs to improve the coordination of interaction in the kind of “energy resource – sector of consumption”. The determination of the tools of effective cooperation is possible by using the functional approach, which based on the intersectoral connection of economic activity. The process of social production represents as a technological chain, so applying a functional approach will prove the key directions of growth efficiency as in the field of generation and in the creation of tangible and intangible benefits.

The main factors of growth of energy efficiency is to improve the quality features of the economic environment: competition, business climate, investment attractiveness, innovation activity. It will create the proper level of motivation for entrepreneurial initiatives in energy efficiency, will prevent ineffective government intervention and excessive administrative influence in the energy sector, and, eventually, will ensure the gradual performance of Ukraine to the best practices of effective energy consumption.

### References

Shevtsov, A.I., Barannik, V.O., Zemlyanyy, M.H., Ryauzova., T.V. (2014). *Enerhoefektyvnist' u rehional'nomu vymiri.*

*Problemy ta perspektyvy. Analitychna dopovid'. Rehional'nyy filial Natsional'noho instytutu stratehichnykh doslidzhen' v m. Dnipropetrovs'ku. – Dnipropetrovs'k, 18-21. Retrieved from <http://www.niss.gov.ua/content/articles/files/energoefekt-b40dc.pdf>*

*Ukraine 2012. Energy policies beyond IEA countries. (2012). OECD/IEA, 2012 International Energy Agency. 9 rue de la Fédération 75739 Paris Cedex 15, France, 33-49. Retrieved from <http://www.iea.org/publications/freepublications/publication/energy-policies-beyond-iea-countries---ukraine-2012.html>*

*Uglublennyy obzor politiki i programm Ukrainy v oblasti energoeffektivnosti. (2013). Sekretariat Energeticheskoy Khartii, Boulevard de la Woluwe, 56 B-1200 Brussels, Belgium, 61-70. Retrieved from [http://sae.gov.ua/documents/Ukraine\\_EE\\_2013\\_RUS.pdf](http://sae.gov.ua/documents/Ukraine_EE_2013_RUS.pdf)*

*Mel'nyk O. Yak Ukrayina zmeshuye zalezhnist' vid importu enerhetychnykh resursiv. (2016). Tsentri doslidzhen' enerhetyky, 17.05.2016 Retrieved from <http://eircenter.com/ua-analiitika/yak-ukrayina-zmeshuye-zalezhnist-vid-importu-energetichnix-resursiv>*

*Yevropeys'kiy enerhorynok: yakoyu ye spravzhnya tsina na haz i elektryku?(2015). Analitychnyy tsentr DiXi Group, 2-7. Retrieved from [http://enref.org/wp-content/uploads/2016/02/EU-UA\\_market\\_study\\_1.pdf](http://enref.org/wp-content/uploads/2016/02/EU-UA_market_study_1.pdf)*

*Maysner, F., Naumenko, D., Radeke, Y. Pidvyshchennya enerhoefektyvnosti v Ukrayini: zmeshennya rehulyuvannya ta stymulyuvannya enerhozberezhennya. (2012). Instytut ekonomichnykh doslidzhen' ta politychnykh konsul'tatsiy. Nimets'ka konsul'tatyvna hrupa. Berlin/Kyyiv, 8-11. Retrieved from [http://www.ier.com.ua/files/publications/Policy\\_papers/German\\_advisory\\_group/2012/PP\\_01\\_2012\\_ukr.pdf](http://www.ier.com.ua/files/publications/Policy_papers/German_advisory_group/2012/PP_01_2012_ukr.pdf)*